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A Macroscopic Physical Model for Self-Initiated Upward Leaders from Tall Grounded Objects and Its Application

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Abstract

This paper presents a macroscopic physical model that can simulate an upward leader initiated from a tall grounded object under thunderclouds. Based on a tri-layer leader channel structure and the energy conservation law, a new equation for estimating the upward leader propagation speed is proposed. Equations for modeling other physical parameters, such as the leader line charge density, leader core radius, leader corona sheath radius, leader current, leader electric field and leader conductance, are also proposed. Besides, a set of initiation and survival criteria for a steady self-initiated upward leader from a tall grounded object is suggested. Based on the suggested criteria and the proposed model, the critical corona and charge amount as well as the minimum height for successful initiation of an upward positive leader (UPL) from a tall grounded object are evaluated and discussed. The model is then used to investigate the general properties of UPLs self-initiated from tall grounded objects with and without the effect of corona space charge layer near the ground under different thunderstorm conditions. The modelling results can well explain the leader properties observed in literature. The model is further tested with two set of experiment data and very promising results are obtained.

Key words: leader initiation, leader propagation, leader modeling, tall grounded object, upward positive leader.